Space Weather Technical Forecast

Issued on Monday, 31 January 2022 at 13:08 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor to Moderate Storms likely day 3 (2nd) from CME arrival. Chance M-flares (R1/R2 Radio Blackouts). Active electron fluence likely day 2 (1st).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Low with a number of C-class flares observed, These originating from AR2936 Eho/Beta near centre disc in the northern hemisphere, AR2939 Dai/Beta near the northeast limb, and AR2940 near the southeast limb. The latter two showing signs of growth and emergent spots as the rotate into view, but are noticeably small than the large AR2936. There is a total of six sunspot regions, however the other three are currently either small and simple or stable. No Earth-directed CMEs were observed in available imagery in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind, as observed at L1 rose from 450km/s to be elevated and generally steady at 510 km/s since 30/2330 UTC. The density was below average, but became average at around 10ppc from 30/2330. The total magnetic field strength (IMF) Bt, was mostly weak between 4-6nT, however the north-south component, Bz, whilst weak, exhibited the structure of a likely passing CME. This included an initial turbulent period before a negative (southward) peak of -5nT around 30/2130 UTC, followed by a gradual rotation back to neutral values. This may have been the late arrival of the CME original forecast as passing on the 30th, which left the Sun on the 27th). Phi angle was generally positive (away from the Sun), but briefly rotated to negative (towards the Sun). Geomagnetic Activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) measured at GOES 16 was at background levels. The high energy electron flux (greater than 2MeV), was at moderate levels for much of the period, but rose to be High from 31/1110 UTC, peaking at 1360 pfu at 31/1155 UTC. The associated electron fluence displayed a steadily rising trend and remained below the Active threshold (1e8 integrated flux), with 2.6e7 recorded at 31/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low solar activity is expected through the period, with a chance of rising to Moderate from further isolated M-class flares .There is a very slight chance of X-class flares. Whilst AR2936 remains the largest region on the disc, this has shown some signs of simplifying, although M-flare activity is also possible from AR2939 and AR2940 near the east limb

Solar Wind / Geomagnetic Activity: CME from M1.1 flare of AR2936 on the 29th expected to arrive early day 3 with a chance late day 2 (29/0400 UTC +/- 9hrs). Otherwise solar winds are expected to ease day 1 and 2, before any CME enhancement occurs. This CME influence will likely persist into day 4 (3rd), before receding later that day. Initially Quiet geomagnetic activity will become Active with likely G1/Minor Storm to G2/Moderate storm intervals with the CME arrival. An isolated G3/Strong storm cannot be ruled out. Activity easing to Quiet to Unsettled later day 4 (3rd).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is

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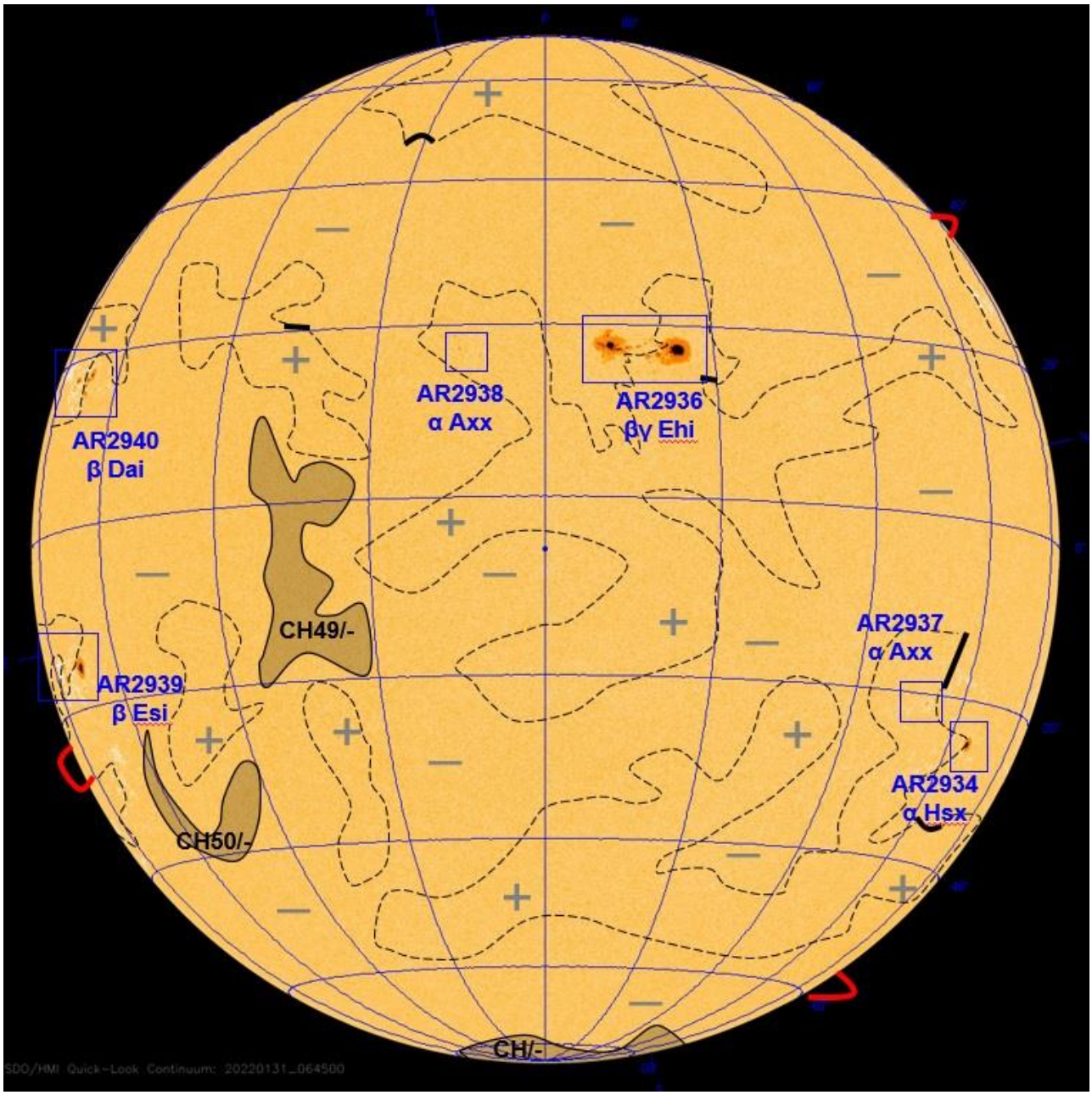
forecast to be at background levels but with a slight chance of rising close to or just above the S1 level, given any significant flaring, predominately from AR2936. The high energy electron flux (greater than 2MeV) is currently High, with a rising trend. This is expected to continue day 1 and 2 (31st and 1st), giving a chance of Active fluence day 2 (2nd) and early day 3 (3rd). The arrival of the CME early day 3 (3rd), is then expected to drop out flux levels, with the fluence levels declining and falling below Active in response.

Figure 1. Solar Analysis Valid 31/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Current solar winds are initially slightly elevated due to the ongoing fast wind of CH47 coupled with a recent weak CME glance. These are expected to gradually ease through day 1 and 2 (31st and 1st), with mainly Quiet geomagnetic activity.

A CME from the M1.1 flare of AR2936 on the 29th, is then forecast to arrive 02/0400 UTC+/-9hrs, (early day 3, with a chance of late day 2) with winds becoming slightly elevated to elevated again, This was an asymmetric halo CME, with good confidence for Earth-directed impact. This could also potentially arrive alongside a weak fast wind enhancement, although the associated coronal hole (CH47) has recently closed and is no longer visible in SDO aia-211 or aia-193 imagery. Influence from this CME is likely to last into day 4 (3rd), before solar winds ease back to background.

Geomagnetic activity is expected to increase with the CME arrival, giving a period of Active conditions, with G1/Minor Storm to G2 Moderate Storm intervals likely (Kp4-6), mainly day 3 (2nd). There is a slight chance of G3 strong storms (Kp7). G1/Minor storm intervals (Kp5) remain possible day 4 (3rd), but likely easing towards Quiet to Unsettled (Kp 1-3).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	30	60	20
Strong	G3	No	1	5	15	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
30/0633	Full (Asymmetric)	AR2936	8N 10E	540 km/s	02/0400 +/-9hrs	CME slightly adjusted after reassessment.

Figure 2: L1 Solar wind speed (left) and Bz (right) showing CME-type structure over last 12hrs.

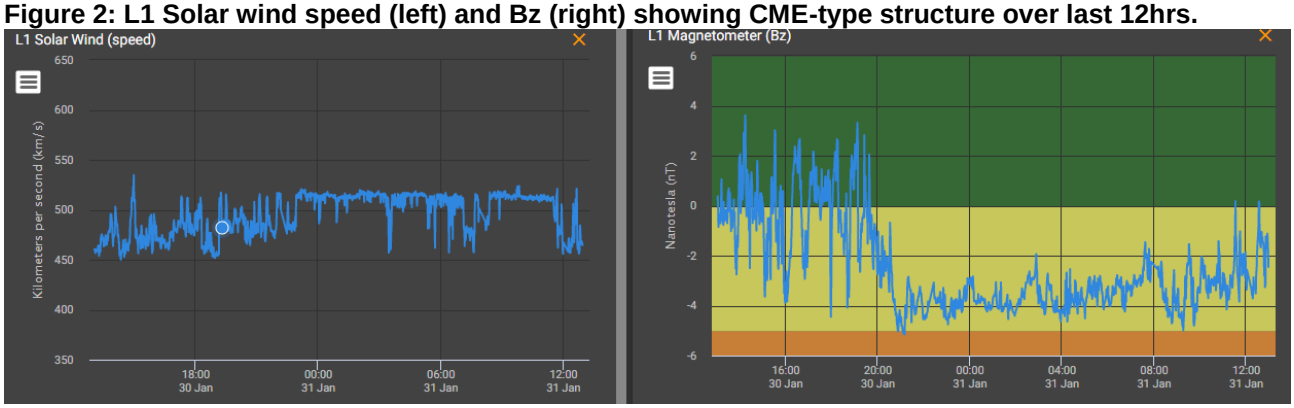

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Figure 3: Enlil with Ensemble. Time set to expected CME arrival.

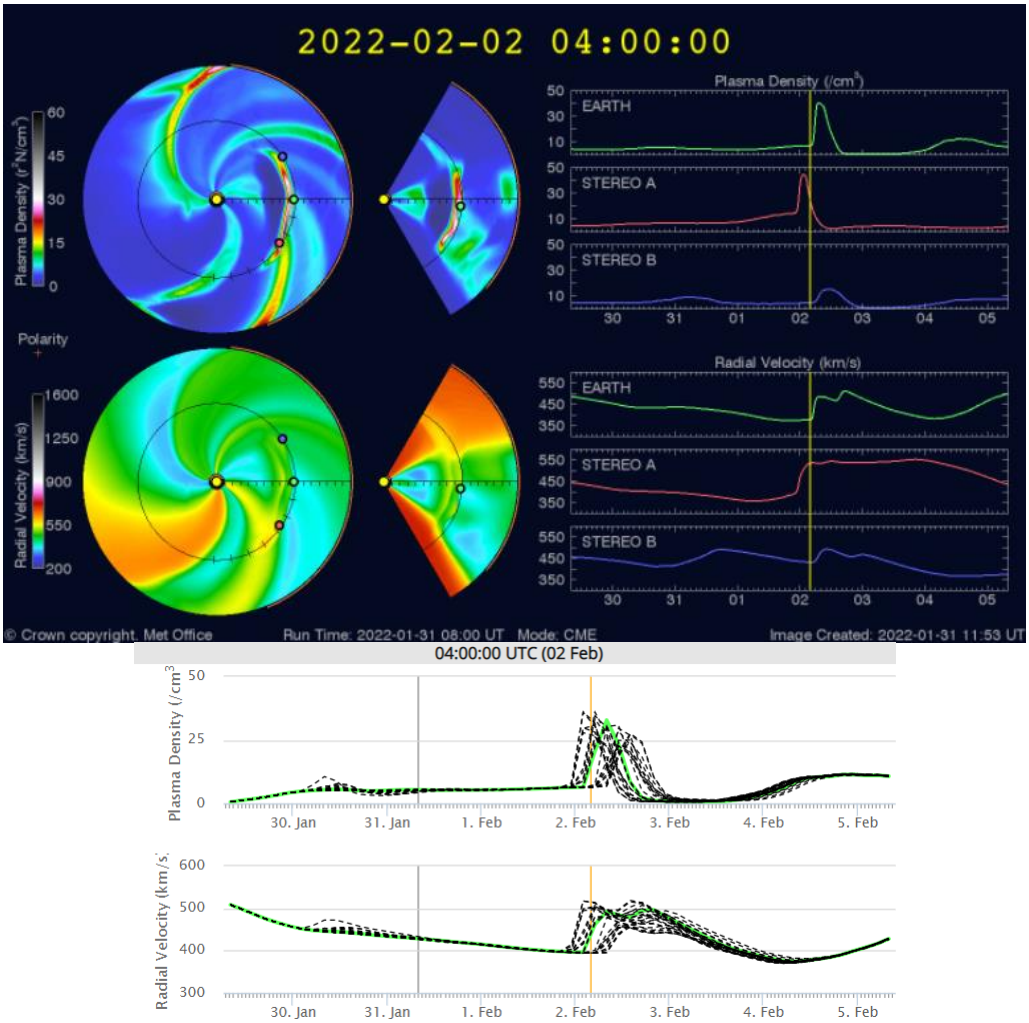
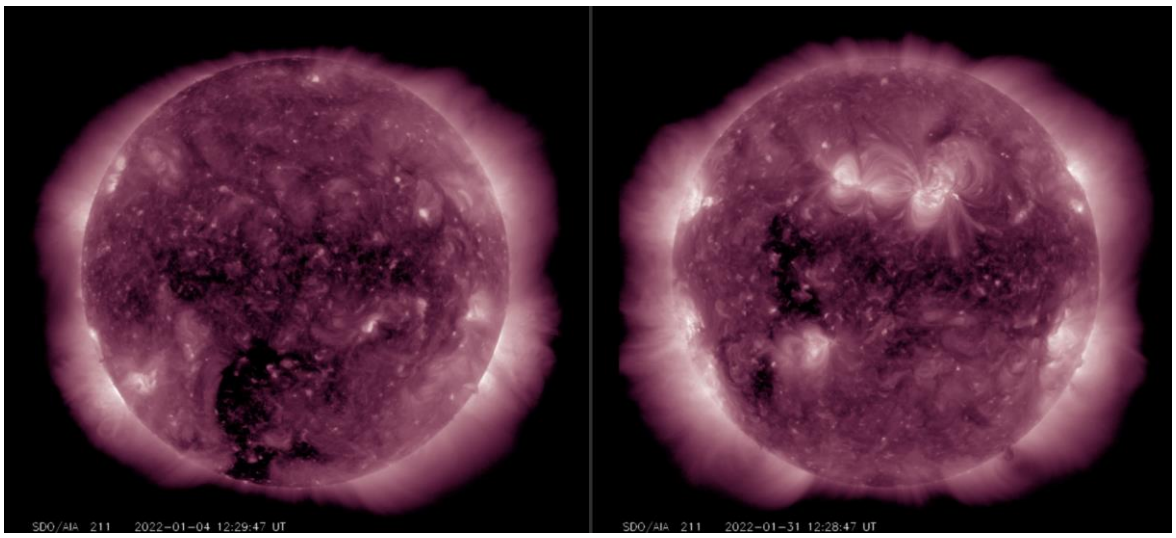


Figure 4: SDO aia-211 of previous and rotation current rotation



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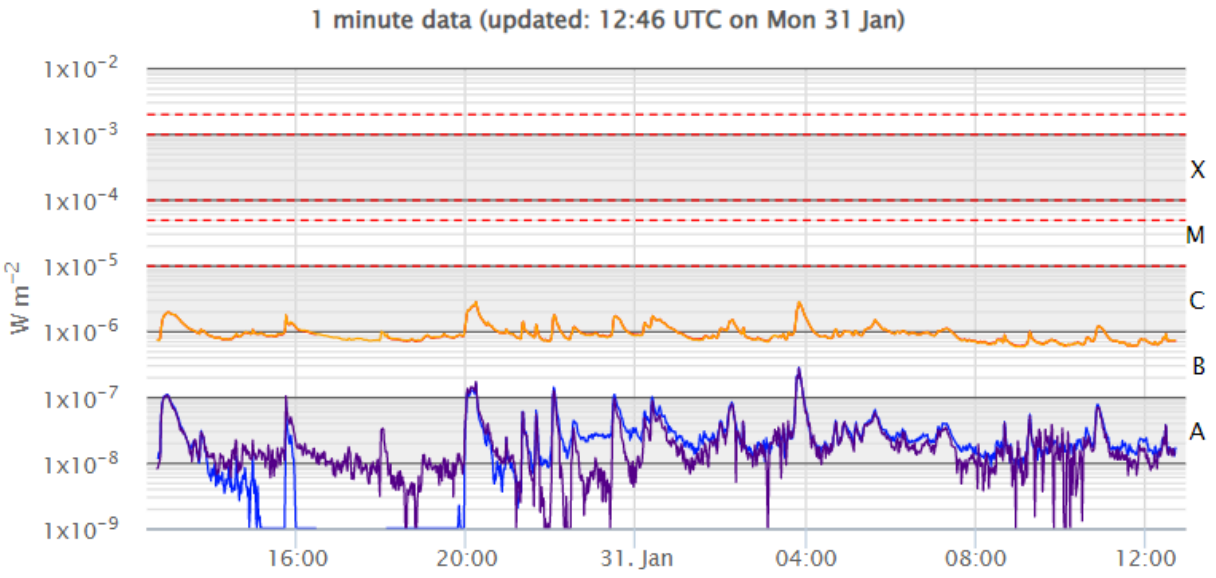
Radio Blackouts - X-Ray Flares:

Solar Activity is Low with six sunspot regions on the visible disc. A number of low C-flares have been observed, from AR2936, AR2939 and AR2940, These will continue to bring a chance of M-class flares (R1/R2 Radio Blackouts) with a slight chance of low X-class flare (R3 Radio Blackout).

AR2936 Eho/Beta was the source of an M1.1 flare on the 29th, although has subsequently simplified to a more open and stable structure. Despite this, it remains a large feature, with the potential to produce high M-class, and potentially low X-class flares. AR939 Dai/Beta is a smaller, but more compact region that recently rotated around the northeast limb, and is showing some signs of growth. AR2940 Esi/Beta has likewise has been rotating into view, but in the southeast, and whilst comprised of fewer spots has a greater longitudinal extent. Both of these regions have the potential for M-class flares. The other regions are either small and simple or mature regions, AR2934 Hsx/alpha, AR2937 Axx/Alpha and AR938/Axx/alpha.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 5: GOES-16/17 X-ray Flux



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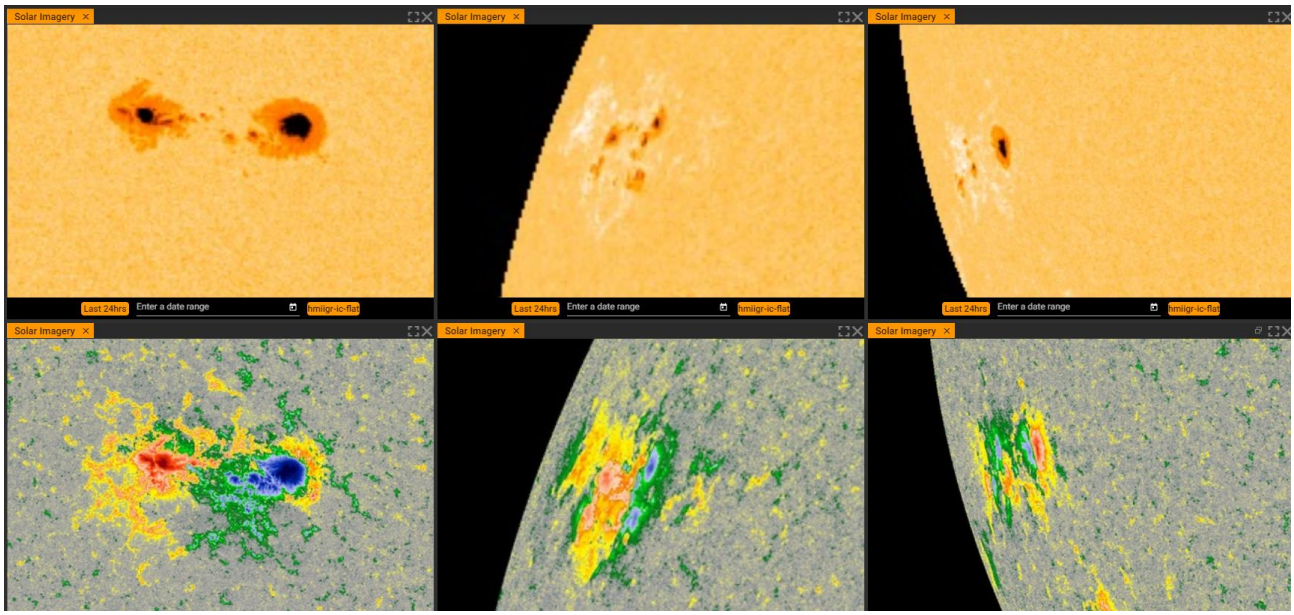
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux, as measured by GOES-16 is at background levels. Solar radiation storms are not likely in the period, however there is a slight chance for proton fluxes to rise given any significant flaring, predominately from AR2936

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 6: SDO Intensitygram and Magnetogram of AR2936, AR2939 and AR2940 respectively



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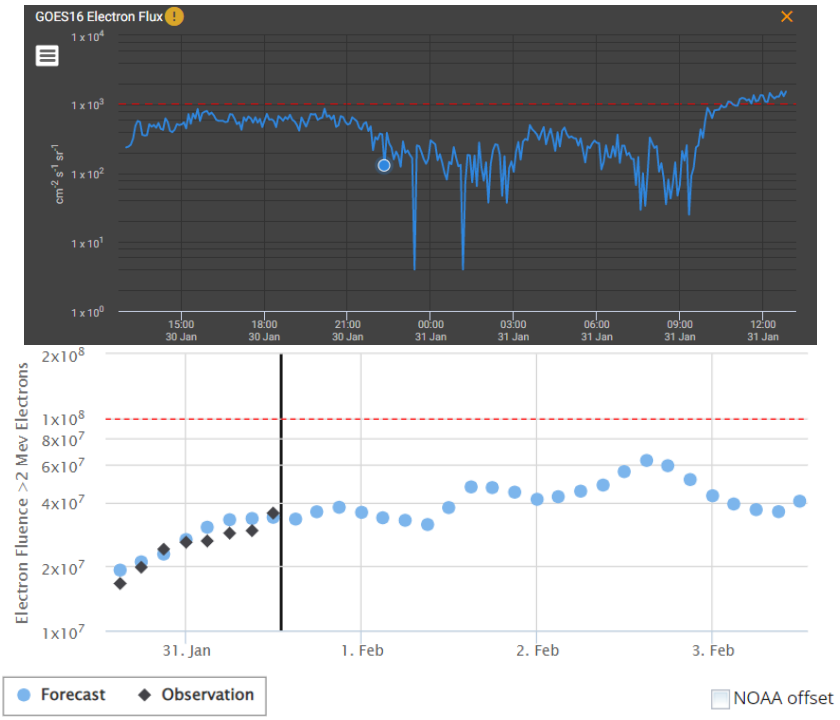
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) as observed by GOES-16 at GEO has exhibited a rising trend from Moderate levels, to be High at time of issue. This is expected to continue through day 1 and 2 (31st and 1st), only falling to Moderate at nocturnal minimum. The arrival of the CME expected 02/0400 UTC+- 9hrs is then expected to cause a drop out in values, before potentially rising again day 4 as the influence of the CME recedes, perhaps reaching high again by the end of the period.

The associated fluence is expected to climb day 1 (31st), to become Active (greater than 1e8 pfu) early day 2 (1st), but with a chance of staying below. Active fluence is then likely to persist until after the arrival of the CME on day 3 (2nd), with confidence then Low for expected fluence response day 4 (3rd). Whilst the current rising trend is suggested by REFM, fluence values are expected to exceed its expectations and likely reach the Active threshold by day 2 (1st).

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	20	70	60	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 7: GOES-16 >2MeV Electron Flux and associated Fluence with REFM



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